

CLAIMS

What is claimed is:

- 1 1. A method of automatically re-provisioning a network element in adaptation to a
2 failure, the method comprising the computer-implemented steps of:
3 identifying a network element that has failed;
4 selecting a substitute network element from among a pool of one or more available
5 network elements;
6 receiving connection configuration information from the identified network element;
7 based on the connection configuration information, re-configuring the substitute
8 network element and one or more switch devices associated with the
9 identified network element, wherein the re-configuring causes the one or more
10 switch devices to change one or more connections from the identified network
11 element to the substitute network element.

- 1 2. A method as recited in Claim 1, wherein the identified network element is one of a
2 plurality of network elements in a cluster that is associated with first and second network
3 switches.

- 1 3. A method as recited in Claim 1, wherein the steps are performed by a cluster manager
2 that is communicatively coupled to a cluster comprising a plurality of active network
3 elements, the pool of one or more available network elements, a first network switch, and a
4 second network switch.

- 1 4. A method as recited in Claim 1, wherein the step of re-configuring comprises the
2 steps of sending a trigger event to the substitute network element that causes the substitute
3 network element to retrieve a configuration over a network connection.

1 5. A method as recited in Claim 1, wherein re-configuring comprises dynamically
2 reconfiguring the selected network element as a logical clone of the identified network
3 element.

1 6. A method as recited in Claim 1, further comprising the step of associating the
2 identified network element with the pool of available network elements.

1 7. A method as recited in Claim 1, further comprising the steps of:
2 sending an initial configuration to the substitute network element;
3 sending a partial accumulated configuration to the substitute network element; and
4 sending instructions that cause the identified network element to reboot based on a
5 configuration setting of a cluster associated with the identified network
6 element.

1 8. A method as recited in Claim 1, further comprising the steps of:
2 receiving first user input in a graphical user interface that associates the network
3 elements in a cluster with a first switch and a second switch;
4 receiving second user input that specifies which network elements are reserved in the
5 pool of available network elements.

1 9. A method as recited in Claim 1, wherein each of the network elements is a network
2 aggregation device or a network access server.

1 10. A method as recited in Claim 1, further comprising repeating the steps for multiple
2 concurrently failed network elements.

1 11. A method as recited in Claim 1, further comprising the steps of:
2 receiving a message specifying a failure of a network element over an event bus on
3 which the network elements publish events and on which a cluster manager
4 subscribes to events;
5 based on the message, identifying the network element that has failed.

1 12. A method as recited in Claim 1, wherein the network switches are asynchronous
2 transfer mode (ATM) switches, and wherein the network elements are routers in a packet-
3 switched network.

1 13. A method of automatically re-provisioning a network element in adaptation to a
2 failure, the method comprising the computer-implemented steps of:
3 receiving first user input that defines a cluster comprising a first network switch, a
4 plurality of network elements, and a second network switch;
5 receiving second user input that specifies one or more of the network elements as a
6 pool of available network elements;
7 identifying a network element that has failed;
8 selecting a substitute network element from among the pool;
9 re-configuring the first network switch and the second network switch, wherein the
10 re-configuring causes the first network switch and second network switch to
11 change one or more connections from the identified network element to the
12 substitute network element.

1 14. A method as recited in Claim 13, wherein the step of re-configuring comprises the
2 steps of sending a trigger event to the substitute network element that causes the substitute
3 network element to retrieve a configuration over a network connection.

1 15. A method as recited in Claim 13, wherein re-configuring comprises dynamically
2 reconfiguring the selected network element as a logical clone of the identified network
3 element.

1 16. A method as recited in Claim 13, further comprising the step of associating the
2 identified network element with the pool of available network elements.

1 17. A method as recited in Claim 13, further comprising the steps of:
2 sending an initial configuration to the substitute network element;
3 sending a partial accumulated configuration to the substitute network element; and
4 sending instructions that cause the identified network element to reboot based on a
5 configuration setting of a cluster associated with the identified network
6 element.

1 18. A method as recited in Claim 13, wherein each of the network elements is a network
2 aggregation device or a network access server.

1 19. A method as recited in Claim 13, further comprising repeating the steps for multiple
2 concurrently failed network elements.

1 20. A method as recited in Claim 13, further comprising the steps of:
2 receiving a message specifying a failure of a network element over an event bus on
3 which the network elements publish events and on which a cluster manager
4 subscribes to events;
5 based on the message, identifying the network element that has failed.

1 21. A method as recited in Claim 13, wherein the network switches are asynchronous
2 transfer mode (ATM) switches, and wherein the network elements are routers in a packet-
3 switched network.

1 22. A computer-readable medium carrying one or more sequences of instructions for
2 automatically re-provisioning a network element in adaptation to a failure, which
3 instructions, when executed by one or more processors, cause the one or more processors to
4 carry out the steps of:
5 identifying a network element that has failed;
6 selecting a substitute network element from among a pool of one or more available
7 network elements;
8 receiving connection configuration information from the identified network element;
9 based on the connection configuration information, re-configuring the substitute
10 network element and one or more switch devices associated with the
11 identified network element, wherein the re-configuring causes the one or more
12 switch devices to change one or more connections from the identified network
13 element to the substitute network element.

1 23. A computer-readable medium as recited in Claim 22, wherein the identified network
2 element is one of a plurality of network elements in a cluster that is associated with first and
3 second network switches.

1 24. A computer-readable medium as recited in Claim 22, wherein the instructions are
2 executed by a cluster manager that is communicatively coupled to a cluster comprising a
3 plurality of active network elements, the pool of one or more available network elements, a
4 first network switch, and a second network switch.

1 25. A computer-readable medium as recited in Claim 22, wherein the instructions for re-
2 configuring further comprise instructions for sending a trigger event to the substitute network
3 element that causes the substitute network element to retrieve a configuration over a network
4 connection.

1 26. A computer-readable medium as recited in Claim 22, wherein the instructions for re-
2 configuring further comprise instructions for dynamically reconfiguring the selected network
3 element as a logical clone of the identified network element.

1 27. A computer-readable medium as recited in Claim 22, further comprising instructions
2 for associating the identified network element with the pool of available network elements.

1 28. A computer-readable medium as recited in Claim 22, further comprising instructions
2 for:
3 sending an initial configuration to the substitute network element;
4 sending a partial accumulated configuration to the substitute network element; and
5 sending instructions that cause the identified network element to reboot based on a
6 configuration setting of a cluster associated with the identified network
7 element.

1 29. A computer-readable medium as recited in Claim 22, further comprising instructions
2 for:
3 receiving first user input in a graphical user interface that associates the network
4 elements in a cluster with a first switch and a second switch;
5 receiving second user input that specifies which network elements are reserved in the
6 pool of available network elements.

1 30. A computer-readable medium as recited in Claim 22, wherein each of the network
2 elements is a network aggregation device or a network access server.

1 31. A computer-readable medium as recited in Claim 22, further comprising instructions
2 for repeatedly executing the instructions for multiple concurrently failed network elements.

1 32. A computer-readable medium as recited in Claim 22, further comprising instructions
2 for performing the steps of:
3 receiving a message specifying a failure of a network element over an event bus on
4 which the network elements publish events and on which a cluster manager
5 subscribes to events;
6 based on the message, identifying the network element that has failed.

1 33. A computer-readable medium as recited in Claim 22, wherein the network switches
2 are asynchronous transfer mode (ATM) switches, and wherein the network elements are
3 routers in a packet-switched network.

1 34. An apparatus for automatically re-provisioning a network element in adaptation to a
2 failure, comprising:
3 means for identifying a network element that has failed;
4 means for selecting a substitute network element from among a pool of one or more
5 available network elements;
6 means for receiving connection configuration information from the identified network
7 element;
8 means for re-configuring the substitute network element and one or more switch
9 devices associated with the identified network element, based on the
10 connection configuration information, wherein the re-configuring causes the
11 one or more switch devices to change one or more connections from the
12 identified network element to the substitute network element.

1 35. An apparatus as recited in Claim 34, wherein the identified network element is one of
2 a plurality of network elements in a cluster that is associated with first and second network
3 switches.

1 36. An apparatus as recited in Claim 34, wherein the apparatus comprises a cluster
2 manager that is communicatively coupled to a cluster comprising a plurality of active
3 network elements, the pool of one or more available network elements, a first network
4 switch, and a second network switch.

1 37. An apparatus as recited in Claim 34, wherein the re-configuring means comprises
2 means for sending a trigger event to the substitute network element that causes the substitute
3 network element to retrieve a configuration over a network connection.

1 38. An apparatus as recited in Claim 34, wherein the re-configuring means comprises
2 means for dynamically reconfiguring the selected network element as a logical clone of the
3 identified network element.

1 39. An apparatus as recited in Claim 34, further comprising means for associating the
2 identified network element with the pool of available network elements.

1 40. An apparatus as recited in Claim 34, further comprising:
2 means for sending an initial configuration to the substitute network element;
3 means for sending a partial accumulated configuration to the substitute network
4 element; and
5 means for sending instructions that cause the identified network element to reboot
6 based on a configuration setting of a cluster associated with the identified
7 network element.

1 41. An apparatus as recited in Claim 34, further comprising:
2 means for receiving first user input in a graphical user interface that associates the
3 network elements in a cluster with a first switch and a second switch;
4 means for receiving second user input that specifies which network elements are
5 reserved in the pool of available network elements.

1 42. An apparatus as recited in Claim 34, wherein each of the network elements is a
2 network aggregation device or a network access server.

1 43. An apparatus as recited in Claim 34, further comprising means for using the other
2 means repeatedly for multiple concurrently failed network elements.

1 44. An apparatus as recited in Claim 34, further comprising:
2 means for receiving a message specifying a failure of a network element over an
3 event bus on which the network elements publish events and on which a
4 cluster manager subscribes to events;
5 means for identifying the network element that has failed, based on the message.

1 45. An apparatus as recited in Claim 34, wherein the network switches are asynchronous
2 transfer mode (ATM) switches, and wherein the network elements are routers in a packet-
3 switched network.

1 46. An apparatus for automatically re-provisioning a network element in adaptation to a
2 failure, comprising:
3 a network interface that is coupled to the data network for receiving one or more packet
4 flows therefrom;
5 a processor;
6 one or more stored sequences of instructions which, when executed by the processor, cause
7 the processor to carry out the steps of:
8 identifying a network element that has failed;
9 selecting a substitute network element from among a pool of one or more available
10 network elements;
11 receiving connection configuration information from the identified network element;

12 based on the connection configuration information, re-configuring the substitute
13 network element and one or more switch devices associated with the
14 identified network element, wherein the re-configuring causes the one or more
15 switch devices to change one or more connections from the identified network
16 element to the substitute network element.

1 47. An apparatus as recited in Claim 46, wherein the identified network element is one of
2 a plurality of network elements in a cluster that is associated with first and second network
3 switches.

1 48. An apparatus as recited in Claim 46, wherein the steps are performed by a cluster
2 manager that is communicatively coupled to a cluster comprising a plurality of active
3 network elements, the pool of one or more available network elements, a first network
4 switch, and a second network switch.

1 49. An apparatus as recited in Claim 46, wherein the step of re-configuring comprises the
2 steps of sending a trigger event to the substitute network element that causes the substitute
3 network element to retrieve a configuration over a network connection.

1 50. An apparatus as recited in Claim 46, wherein re-configuring comprises dynamically
2 reconfiguring the selected network element as a logical clone of the identified network
3 element.

1 51. An apparatus as recited in Claim 46, further comprising the step of associating the
2 identified network element with the pool of available network elements.

1 52. An apparatus as recited in Claim 46, further comprising the steps of:
2 sending an initial configuration to the substitute network element;
3 sending a partial accumulated configuration to the substitute network element; and

4 sending instructions that cause the identified network element to reboot based on a
5 configuration setting of a cluster associated with the identified network
6 element.

1 53. An apparatus as recited in Claim 46, further comprising the steps of:
2 receiving first user input in a graphical user interface that associates the network
3 elements in a cluster with a first switch and a second switch;
4 receiving second user input that specifies which network elements are reserved in the
5 pool of available network elements.

1 54. An apparatus as recited in Claim 46, wherein each of the network elements is a
2 network aggregation device or a network access server.

1 55. An apparatus as recited in Claim 46, further comprising repeating the steps for
2 multiple concurrently failed network elements.

1 56. An apparatus as recited in Claim 46, further comprising the steps of:
2 receiving a message specifying a failure of a network element over an event bus on
3 which the network elements publish events and on which a cluster manager
4 subscribes to events;
5 based on the message, identifying the network element that has failed.

1 57. An apparatus as recited in Claim 46, wherein the network switches are asynchronous
2 transfer mode (ATM) switches, and wherein the network elements are routers in a packet-
3 switched network.